OIPE
FEB 21 2006
PATENT & TRADEMARK OFFICE

FIG. 1

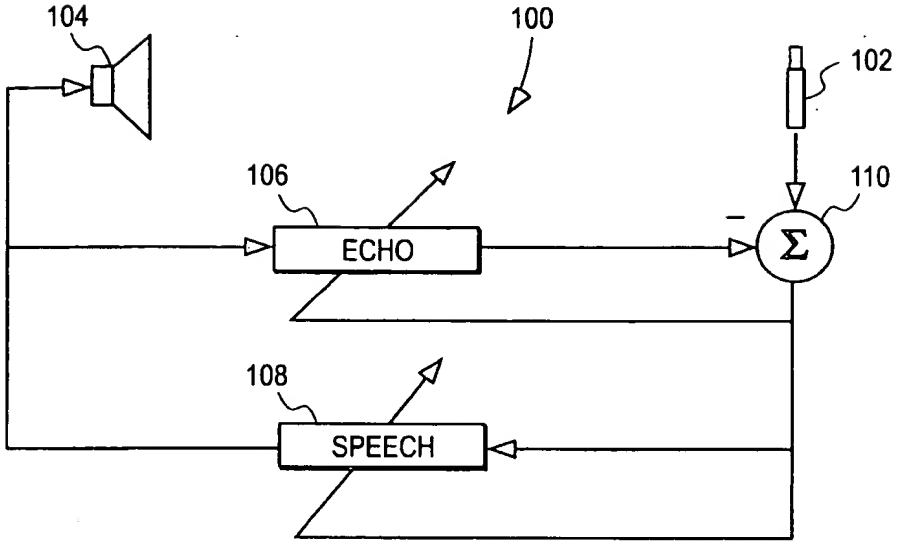


FIG. 2

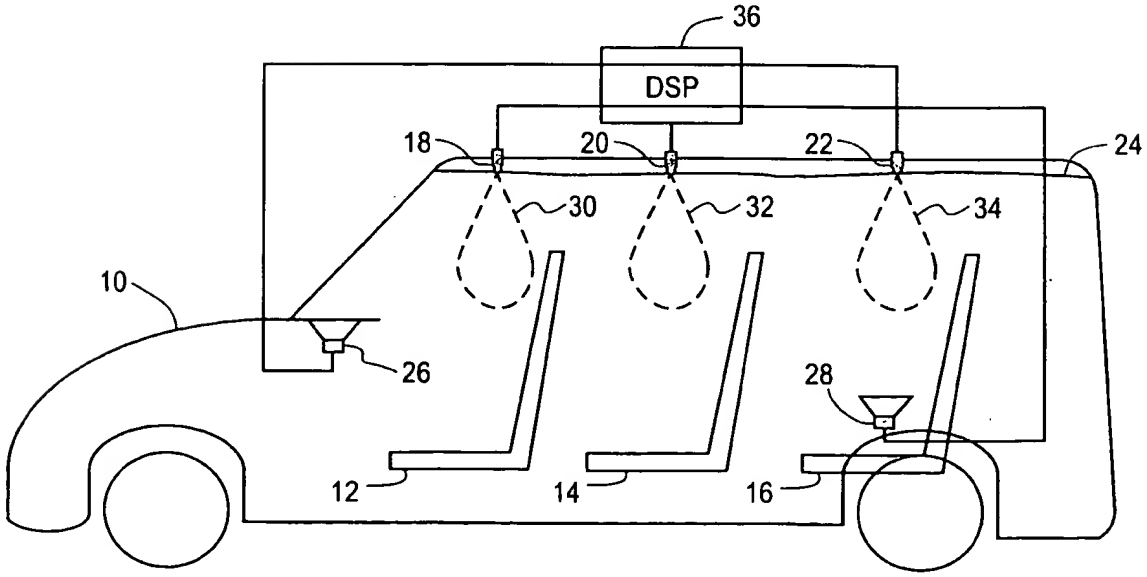


FIG. 3

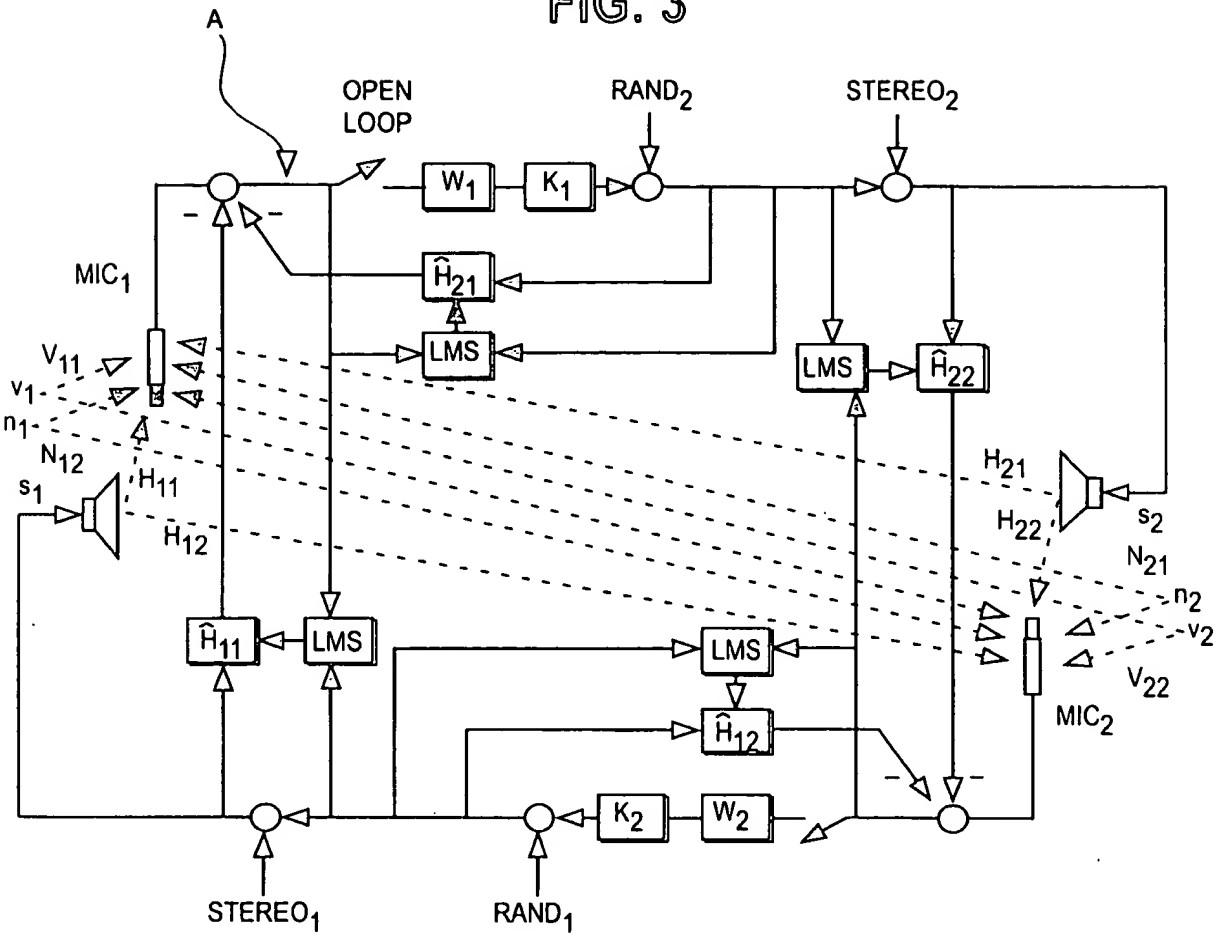
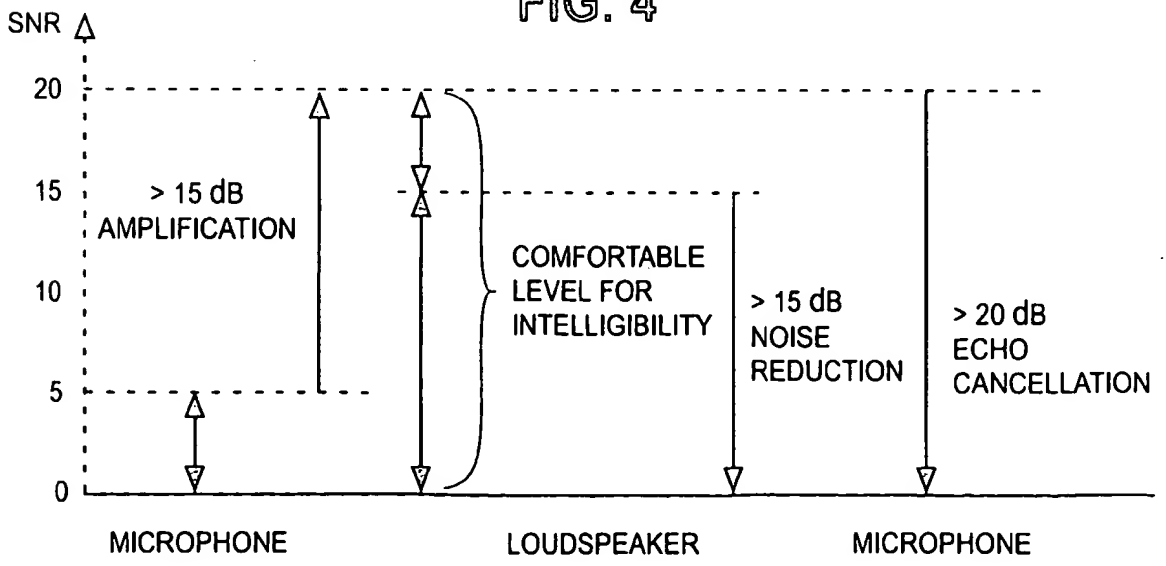

A
OPEN LOOP
RAND2
STEREO2
W1
K1
MIC1
Ĥ21
LMS
V11
v1
n1
N12
H11
s1
H12
LMS
Ĥ22
H21
H22
s2
N21
n2
v2
V22
MIC2
Ĥ11
LMS
LMS
Ĥ12
K2
W2
STEREO1
RAND1

FIG. 4


SNR
20
15
10
5
0
> 15 dB AMPLIFICATION
COMFORTABLE LEVEL FOR INTELLIGIBILITY
> 15 dB NOISE REDUCTION
> 20 dB ECHO CANCELLATION
MICROPHONE
LOUDSPEAKER
MICROPHONE

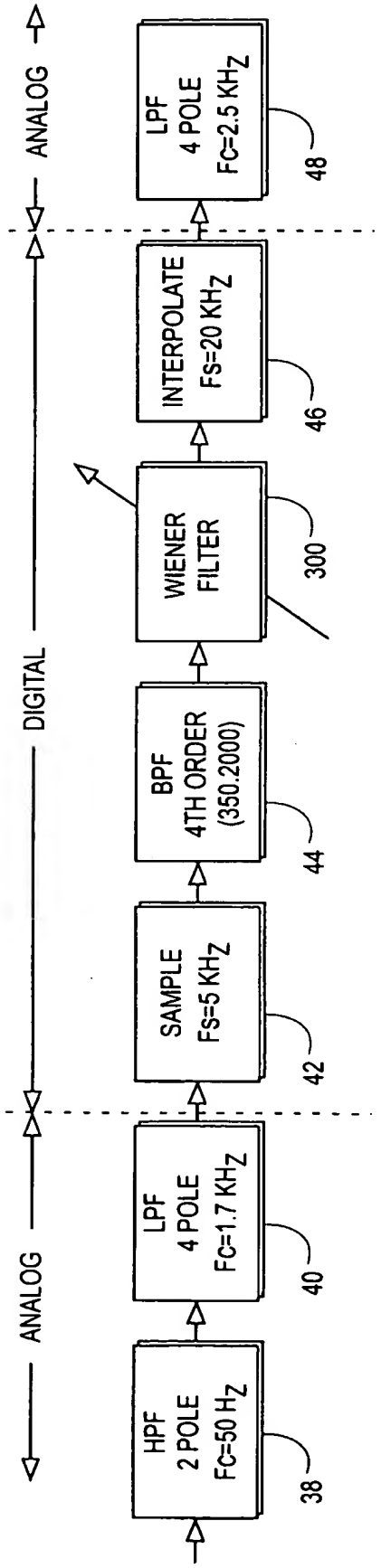

ANALOG
DIGITAL
ANALOG
HPF
2 POLE
Fc=50 Hz
38
LPF
4 POLE
Fc=1.7 KHz
40
SAMPLE
Fs=5 KHz
42
BPF
4TH ORDER
(350.2000)
44
WIENER
FILTER
300
INTERPOLATE
Fs=20 KHz
46
LPF
4 POLE
Fc=2.5 KHz
48

FIG. 5

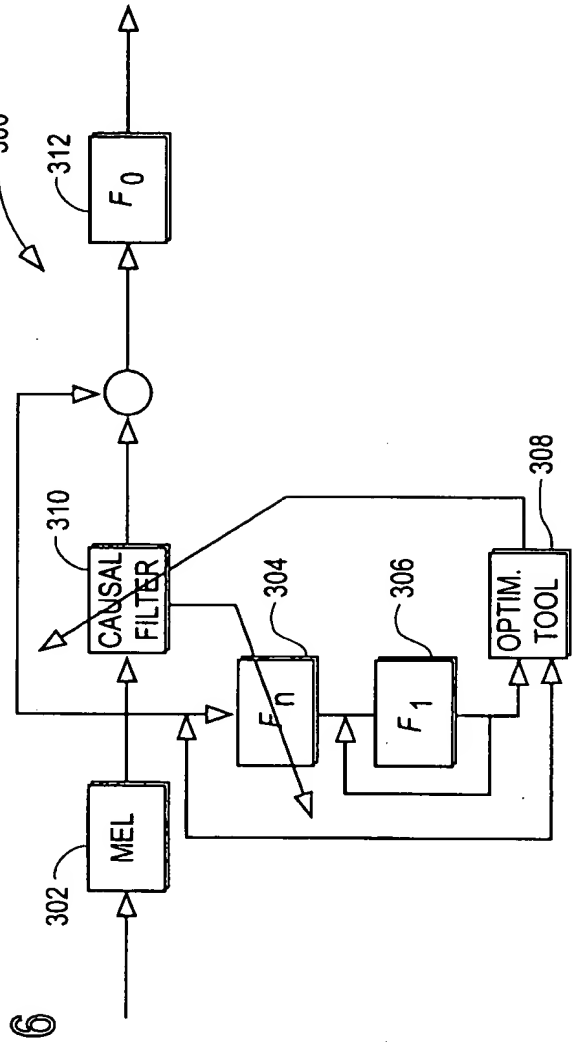

300
312
F_0
310
CAUSAL
FILTER
304
F_n
306
F_1
308
OPTIM.
TOOL
302
MEL

FIG. 6

FIG. 7

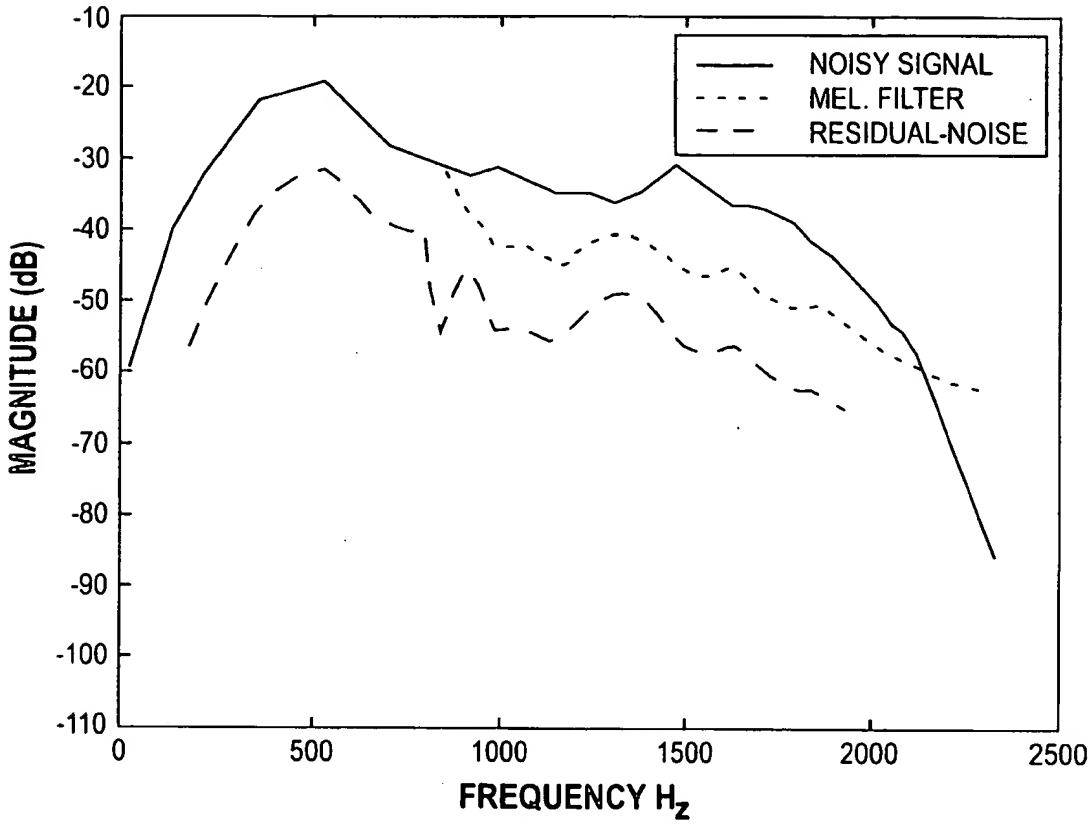

NOISY SIGNAL
MEL. FILTER
RESIDUAL-NOISE
MAGNITUDE (dB)
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
0
500
1000
1500
2000
2500
FREQUENCY Hz

FIG. 8

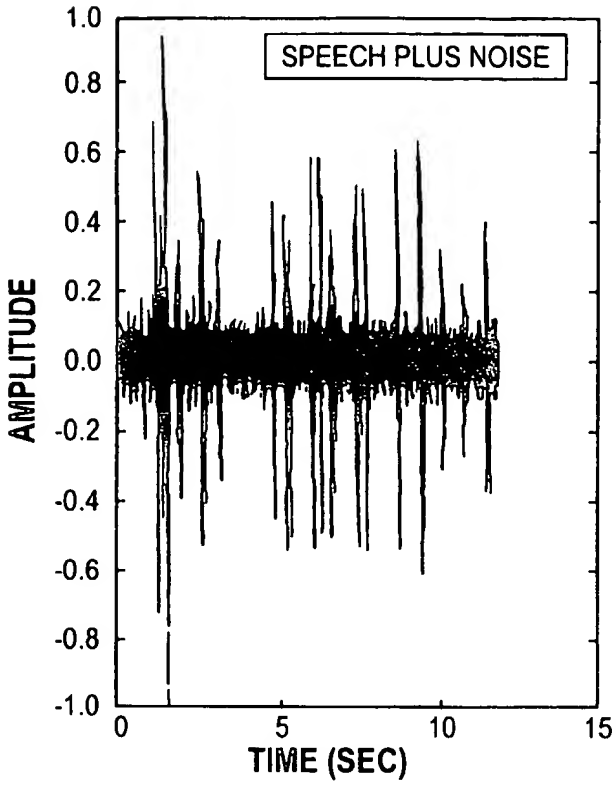

SPEECH PLUS NOISE
AMPLITUDE
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
0
5
10
15
TIME (SEC)

FIG. 9

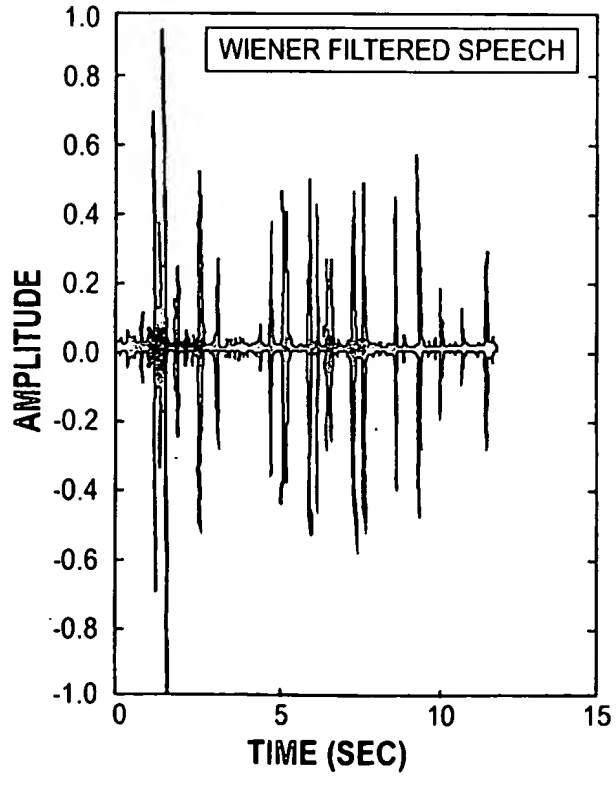

WIENER FILTERED SPEECH
AMPLITUDE
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
0
5
10
15
TIME (SEC)

FIG. 10

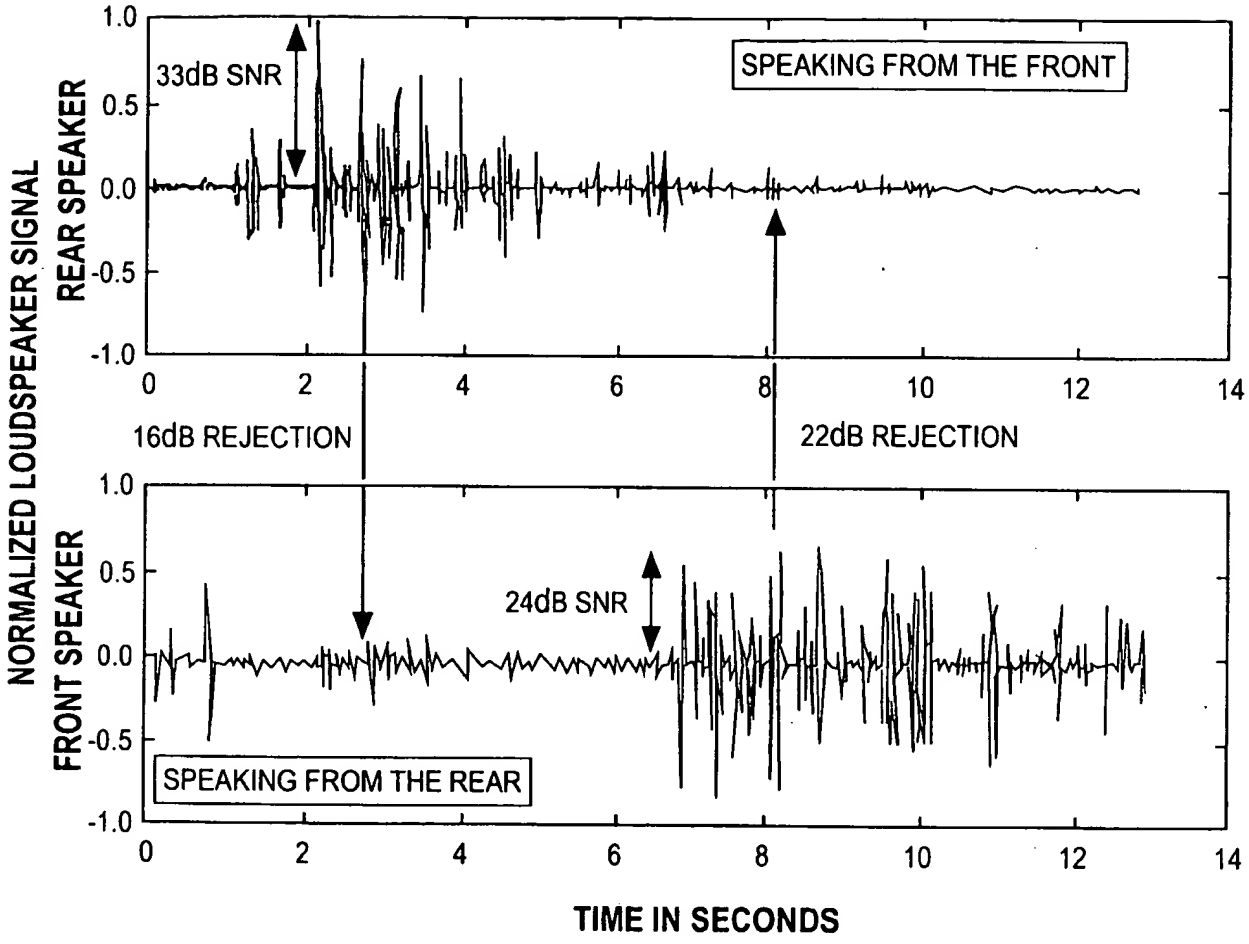

NORMALIZED LOUDSPEAKER SIGNAL
REAR SPEAKER
FRONT SPEAKER
33dB SNR
SPEAKING FROM THE FRONT
16dB REJECTION
22dB REJECTION
24dB SNR
SPEAKING FROM THE REAR
1.0
0.5
0.0
-0.5
-1.0
0
2
4
6
8
10
12
14
TIME IN SECONDS

FIG. 11

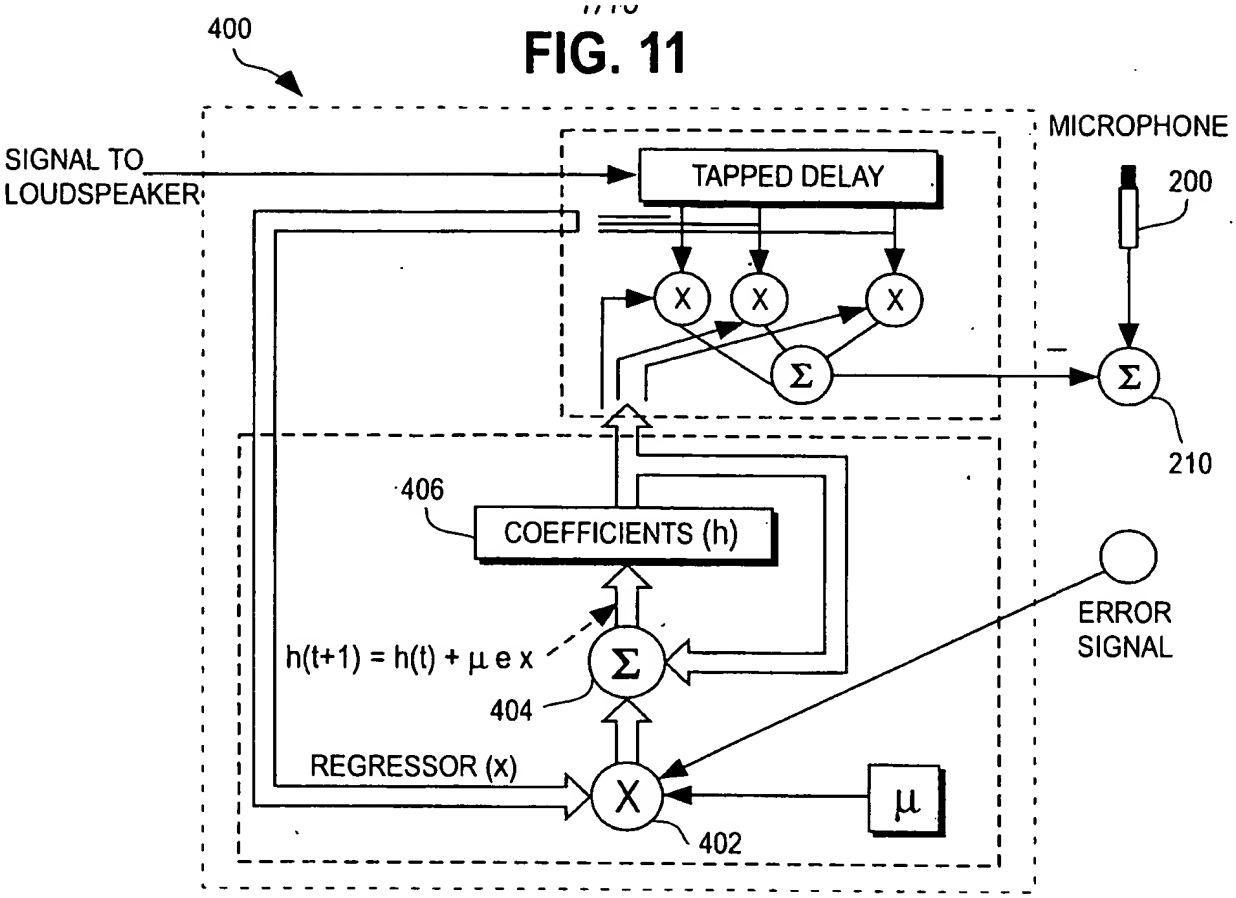

400
SIGNAL TO LOUDSPEAKER
TAPPED DELAY
MICROPHONE
200
X
X
X
Σ
Σ
210
406
COEFFICIENTS (h)
ERROR SIGNAL
h(t+1) = h(t) + μ e x
Σ
404
REGRESSOR (x)
X
μ
402

FIG. 12

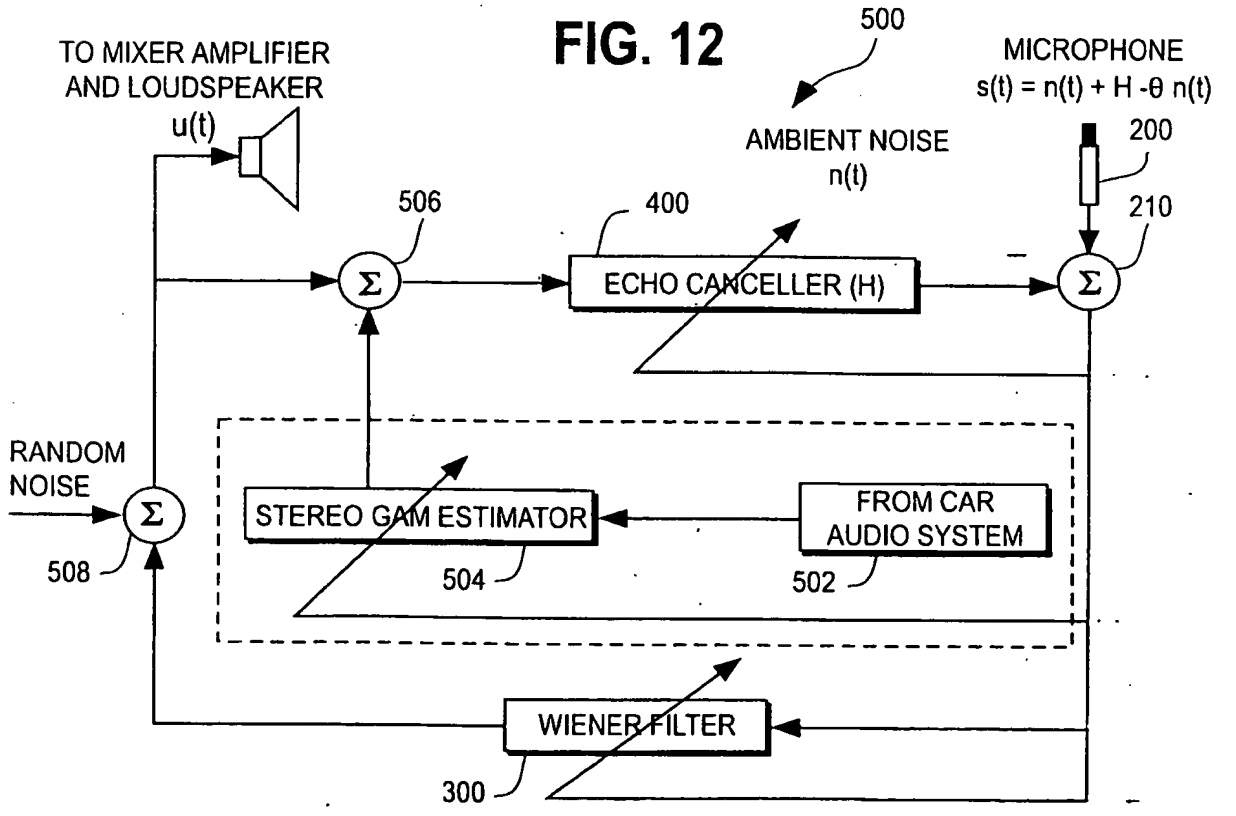

500
TO MIXER AMPLIFIER AND LOUDSPEAKER
u(t)
AMBIENT NOISE
n(t)
MICROPHONE
s(t) = n(t) + H -θ n(t)
200
506
400
210
Σ
ECHO CANCELLER (H)
Σ
RANDOM NOISE
Σ
STEREO GAM ESTIMATOR
FROM CAR AUDIO SYSTEM
508
504
502
WIENER FILTER
300

FIG. 13

```
m=20;delays=30;sig=.00;n=170;
y=filter(h,1,r)+sig*n;
htp1=ht(1:delays+m);
pn=eye(m);
L=length(ht);
ind=delays+m:m:n;
lind=length(ind);
kg=zeros(m,(lind-1) *m+1);

for j=1:lind
ind0(1:m,j)=[(j-1) *m+1:j *m] +delays;
end
htemp=ht(ind0);

for k-200:10000
ind1=k-ind0;
[htemp(:,1)k0,pn,an]=rls1(pn,y(k-1),r(ind1(:,1)),htemp(:,1),1);

for l=(ind-1) *m:-1:1
kg(:,l+1)=kg(:,l):
end

kg(:,1)=k0;

for j=2:lind
htemp(:,j)=htemp(:,j)+kg(:,(j-1) *m+1)*(an-htemp(:,j)' *r(ind1(:,j)));
end
```

FIG. 14

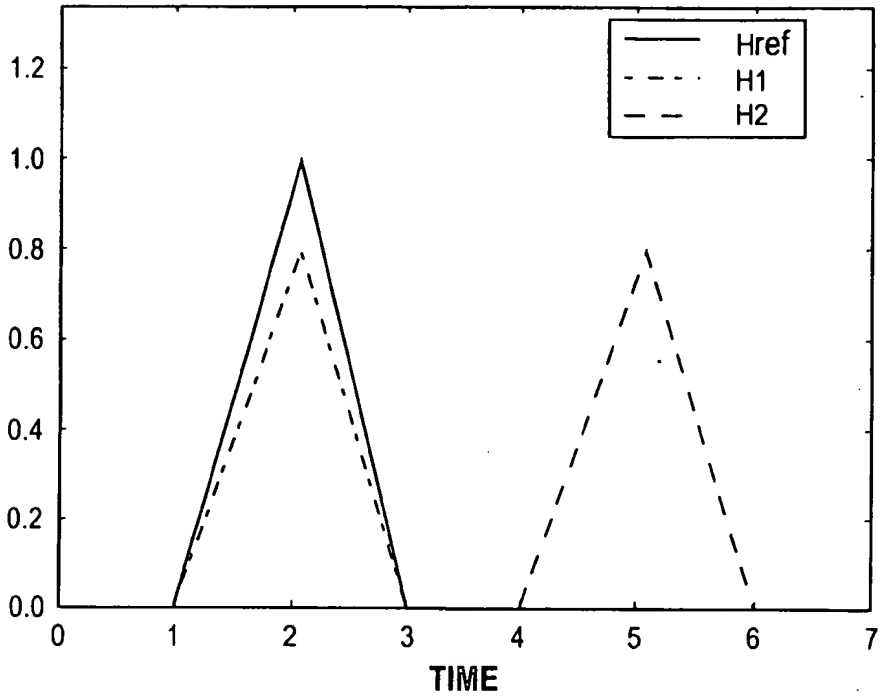

Href
H1
H2
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
1
2
3
4
5
6
7
TIME

FIG. 15

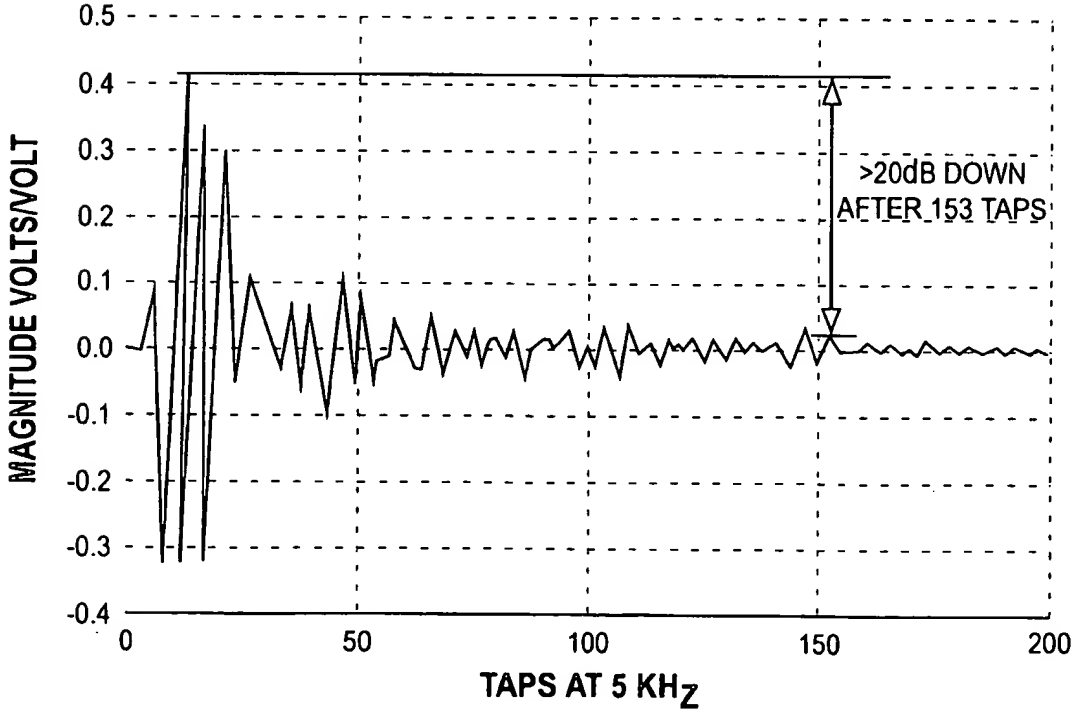

0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
MAGNITUDE VOLTS/VOLT
>20dB DOWN
AFTER 153 TAPS
0
50
100
150
200
TAPS AT 5 KHz

FIG. 16

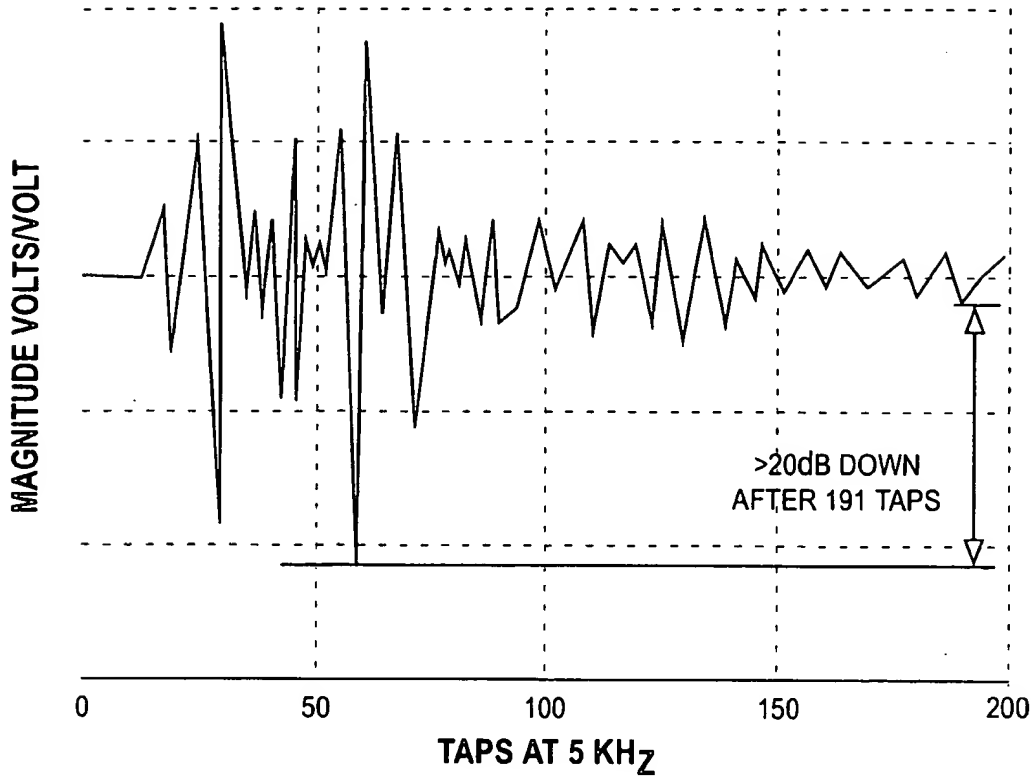

MAGNITUDE VOLTS/VOLT
>20dB DOWN
AFTER 191 TAPS
0
50
100
150
200
TAPS AT 5 KHz

FIG. 17

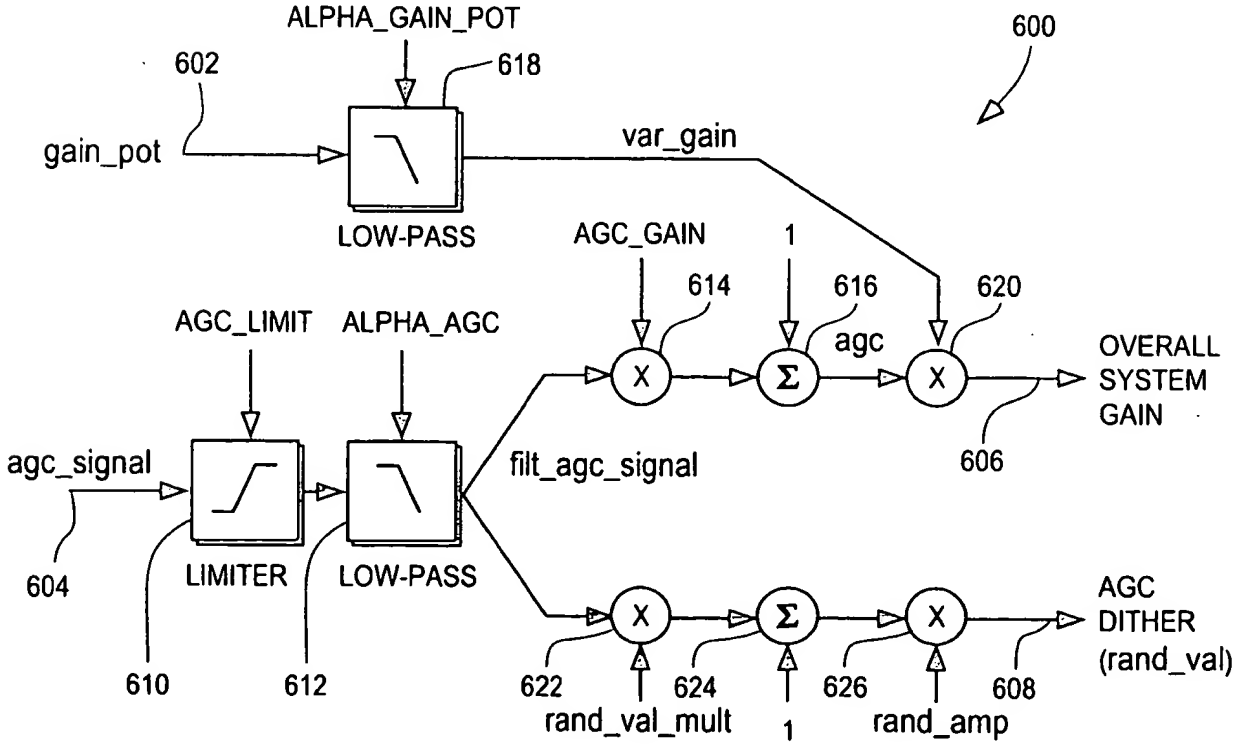

ALPHA_GAIN_POT
600
602
618
gain_pot
var_gain
LOW-PASS
AGC_GAIN
1
614
616
620
AGC_LIMIT
ALPHA_AGC
agc
OVERALL
SYSTEM
GAIN
agc_signal
filt_agc_signal
606
604
LIMITER
LOW-PASS
AGC
DITHER
(rand_val)
610
612
622
624
626
608
rand_val_mult
1
rand_amp

FIG. 18

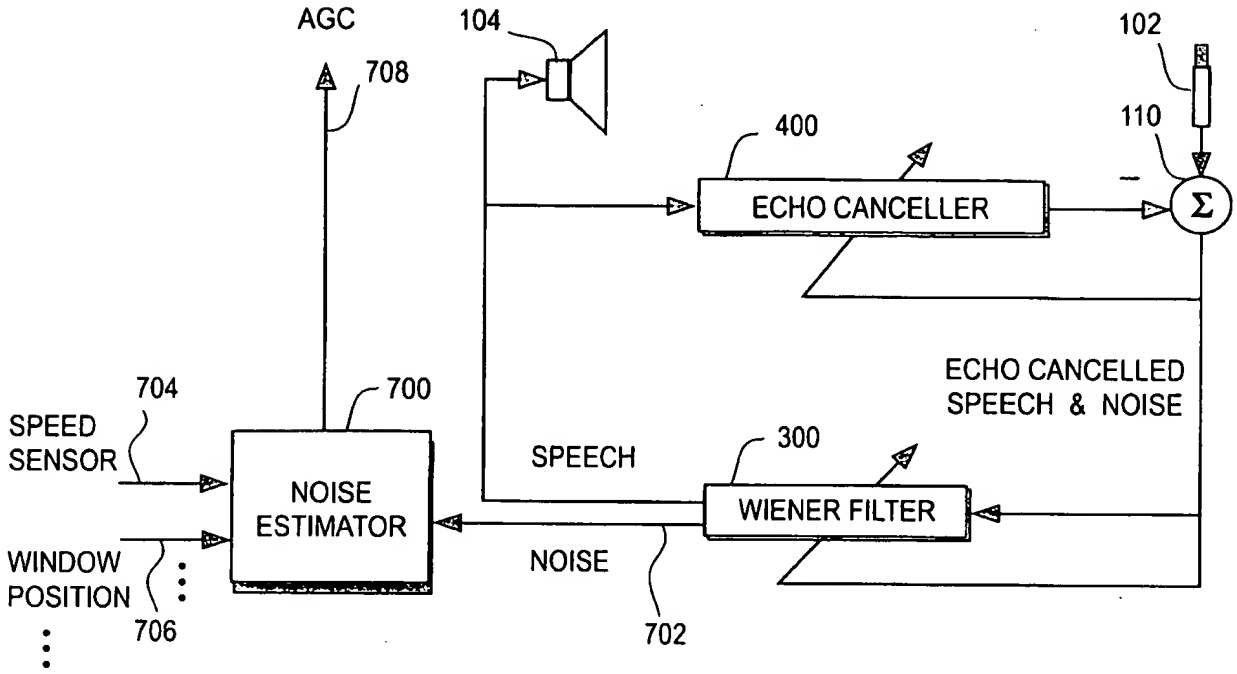

AGC
708
104
102
110
400
ECHO CANCELLER
Σ
ECHO CANCELLED
SPEECH & NOISE
704
SPEED
SENSOR
700
NOISE
ESTIMATOR
SPEECH
300
WIENER FILTER
WINDOW
POSITION
706
NOISE
702

FIG. 19

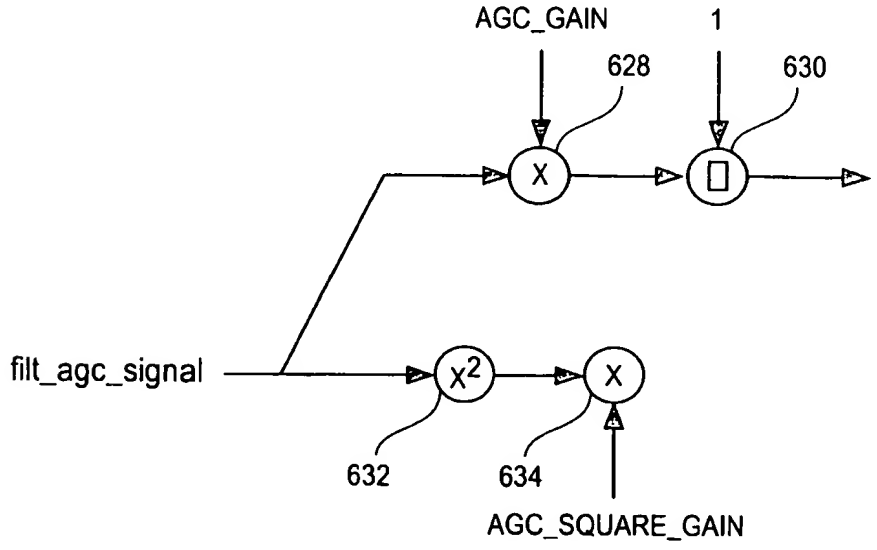

AGC_GAIN
1
628
630
X
filt_agc_signal
X2
X
632
634
AGC_SQUARE_GAIN

FIG. 20

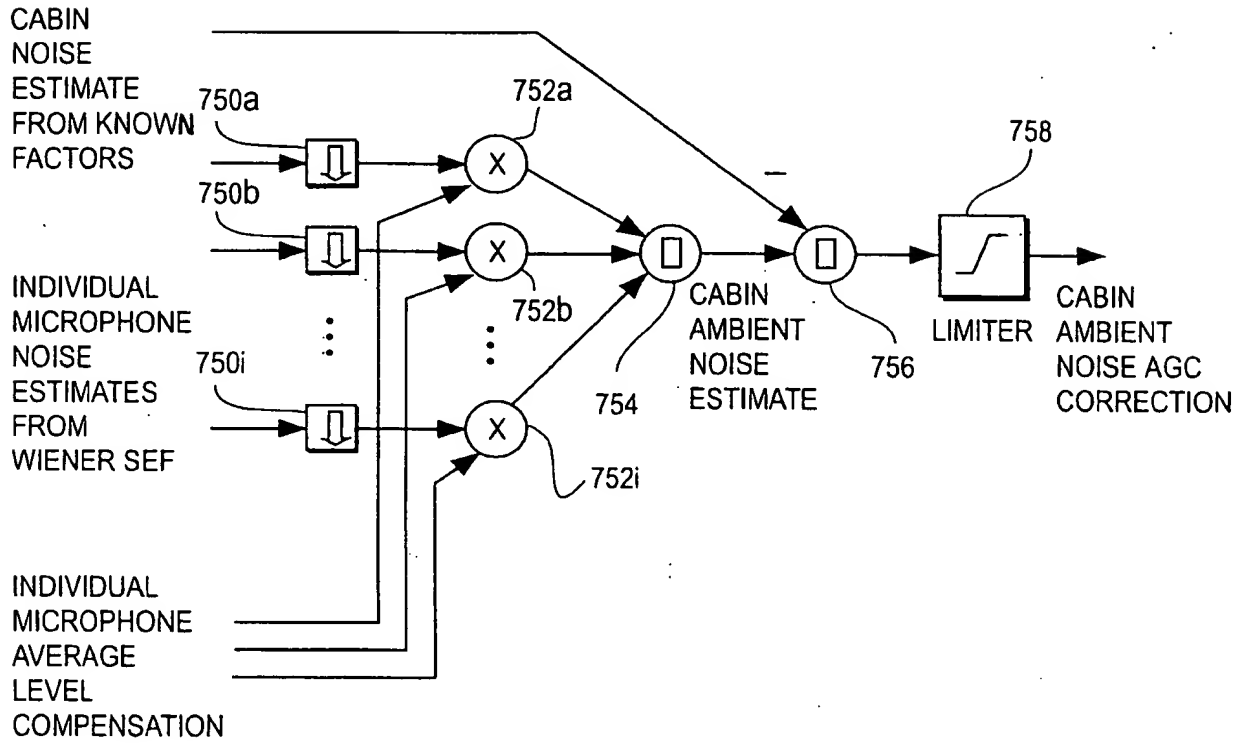

CABIN NOISE ESTIMATE FROM KNOWN FACTORS
750a
752a
758
750b
INDIVIDUAL MICROPHONE NOISE ESTIMATES FROM WIENER SEF
750i
752b
754
CABIN AMBIENT NOISE ESTIMATE
756
LIMITER
CABIN AMBIENT NOISE AGC CORRECTION
752i
INDIVIDUAL MICROPHONE AVERAGE LEVEL COMPENSATION

FIG. 21

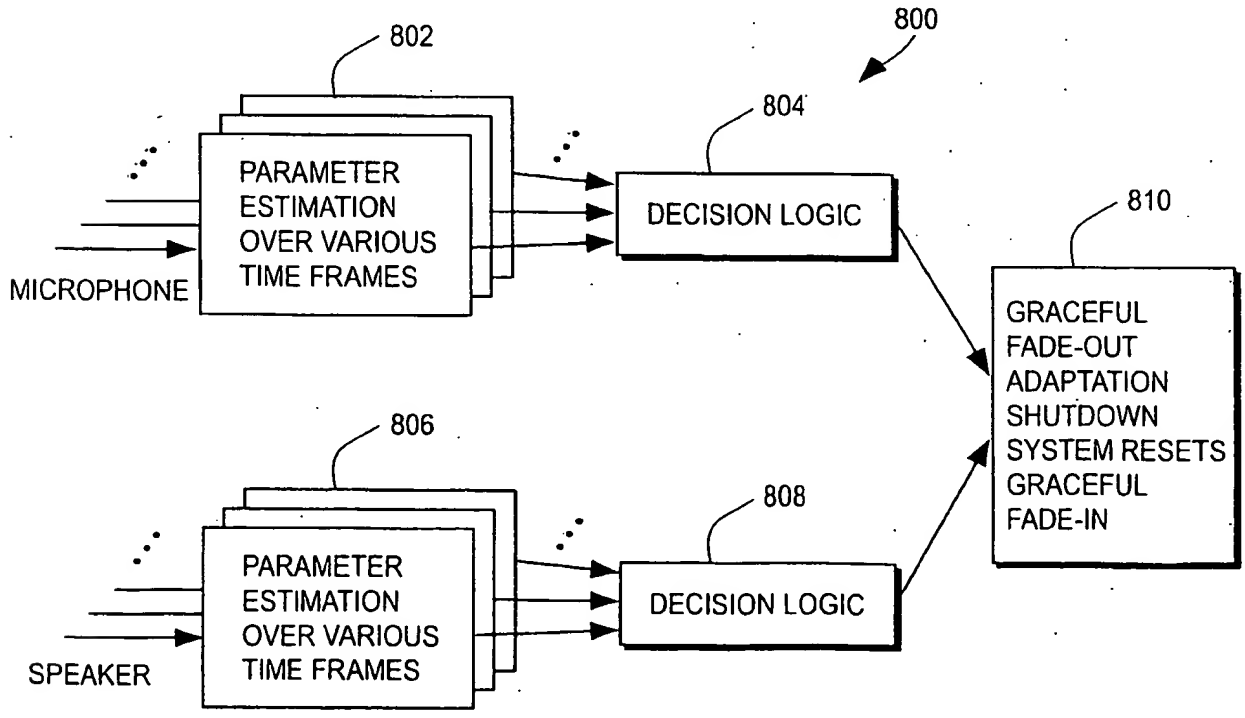

800
802
804
PARAMETER ESTIMATION OVER VARIOUS TIME FRAMES
MICROPHONE
DECISION LOGIC
810
GRACEFUL FADE-OUT ADAPTATION SHUTDOWN SYSTEM RESETS GRACEFUL FADE-IN
806
808
PARAMETER ESTIMATION OVER VARIOUS TIME FRAMES
SPEAKER
DECISION LOGIC

FIG. 22

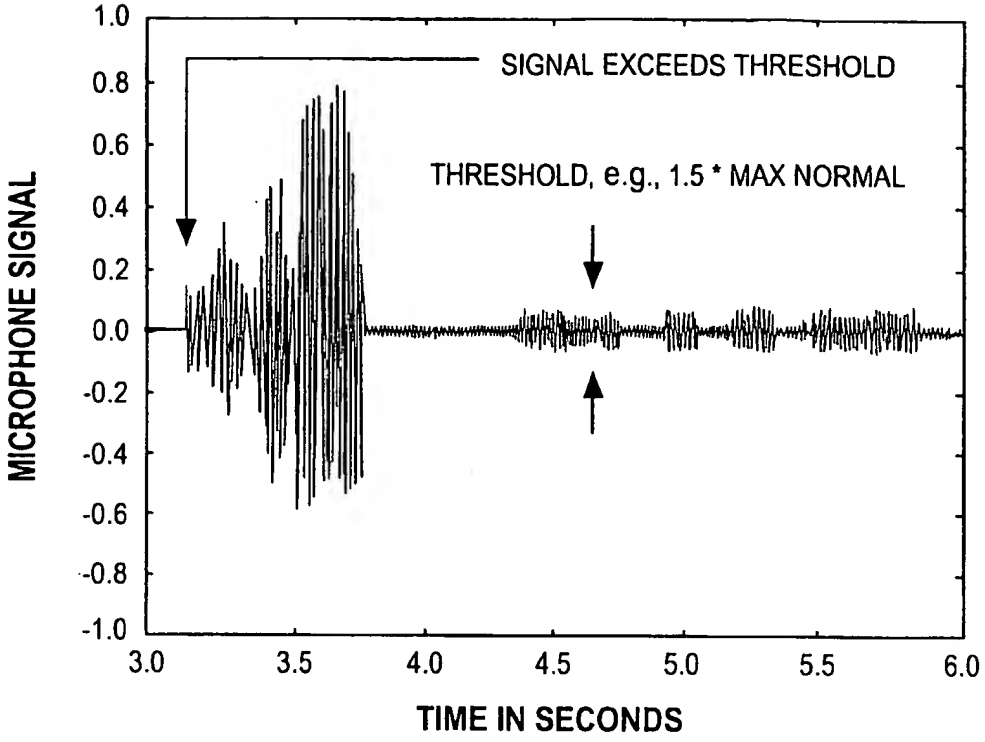

SIGNAL EXCEEDS THRESHOLD
THRESHOLD, e.g., 1.5 * MAX NORMAL
MICROPHONE SIGNAL
TIME IN SECONDS
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
3.0
3.5
4.0
4.5
5.0
5.5
6.0

FIG. 23

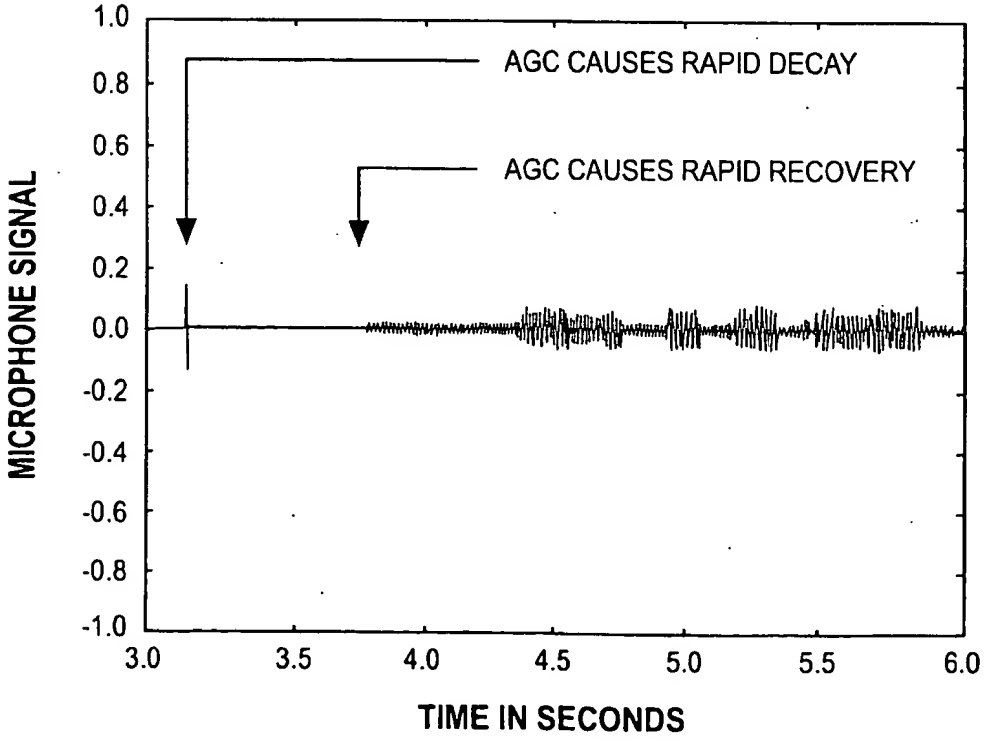

AGC CAUSES RAPID DECAY
AGC CAUSES RAPID RECOVERY
MICROPHONE SIGNAL
TIME IN SECONDS
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
3.0
3.5
4.0
4.5
5.0
5.5
6.0

FIG. 24

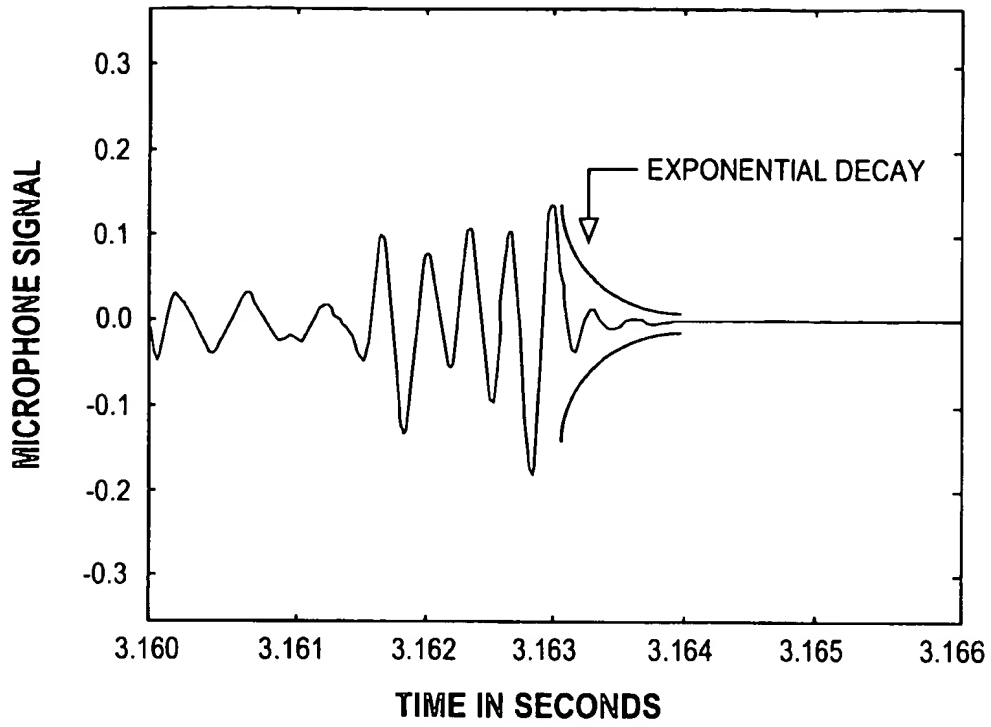

MICROPHONE SIGNAL
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
EXPONENTIAL DECAY
3.160
3.161
3.162
3.163
3.164
3.165
3.166
TIME IN SECONDS

FIG. 25

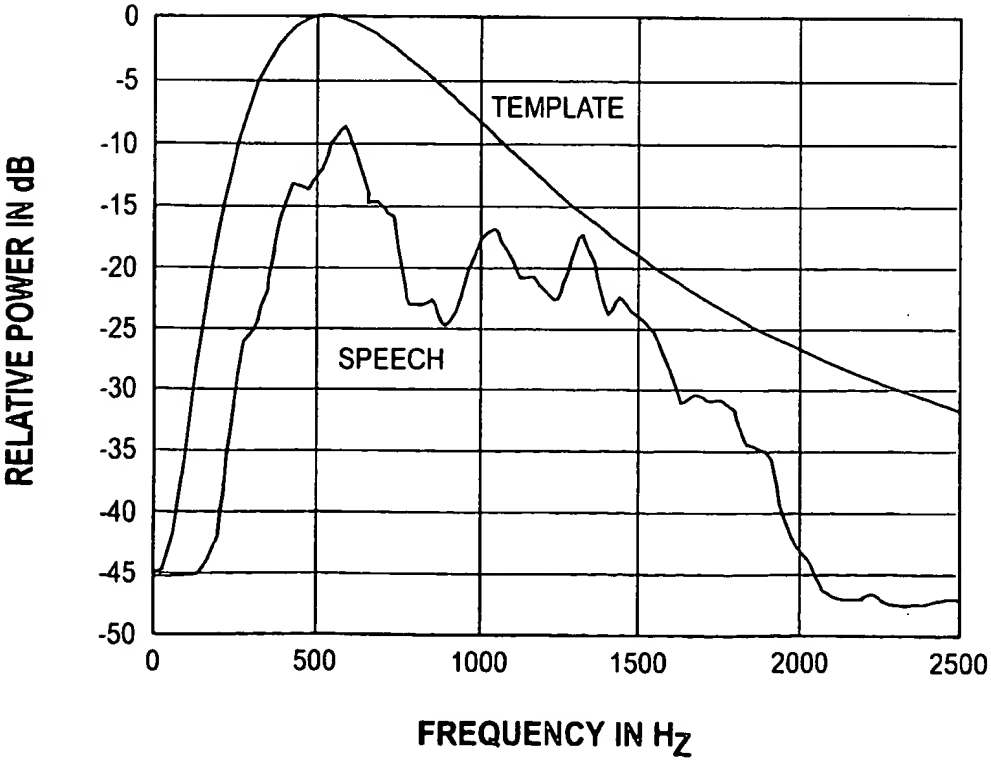

RELATIVE POWER IN dB
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
TEMPLATE
SPEECH
0
500
1000
1500
2000
2500
FREQUENCY IN Hz

FIG. 26

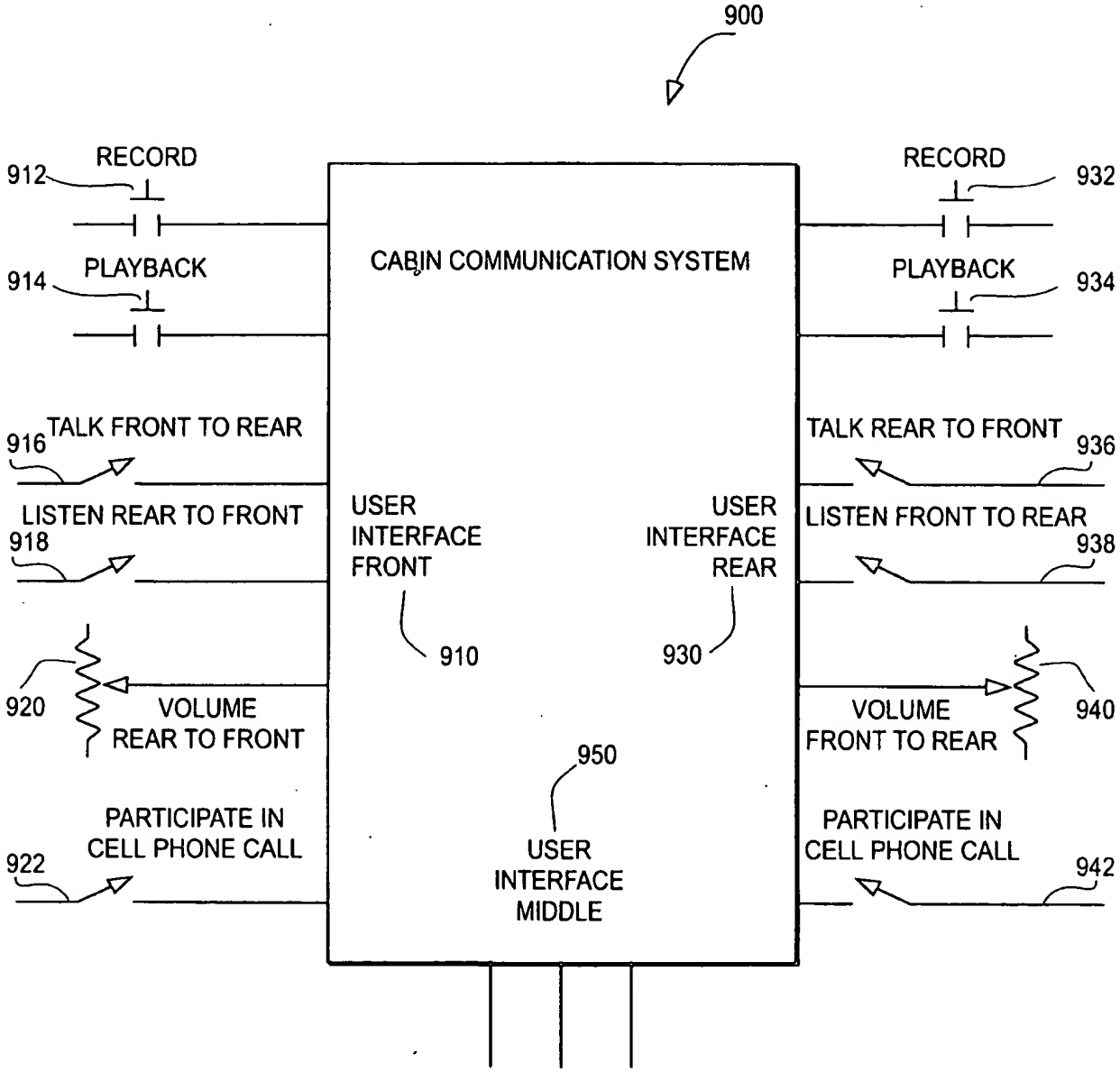

900
RECORD
912
PLAYBACK
914
TALK FRONT TO REAR
916
LISTEN REAR TO FRONT
918
920
VOLUME
REAR TO FRONT
PARTICIPATE IN
CELL PHONE CALL
922
CABIN COMMUNICATION SYSTEM
USER
INTERFACE
FRONT
910
USER
INTERFACE
REAR
930
950
USER
INTERFACE
MIDDLE
RECORD
932
PLAYBACK
934
TALK REAR TO FRONT
936
LISTEN FRONT TO REAR
938
VOLUME
FRONT TO REAR
940
PARTICIPATE IN
CELL PHONE CALL
942

FIG. 27

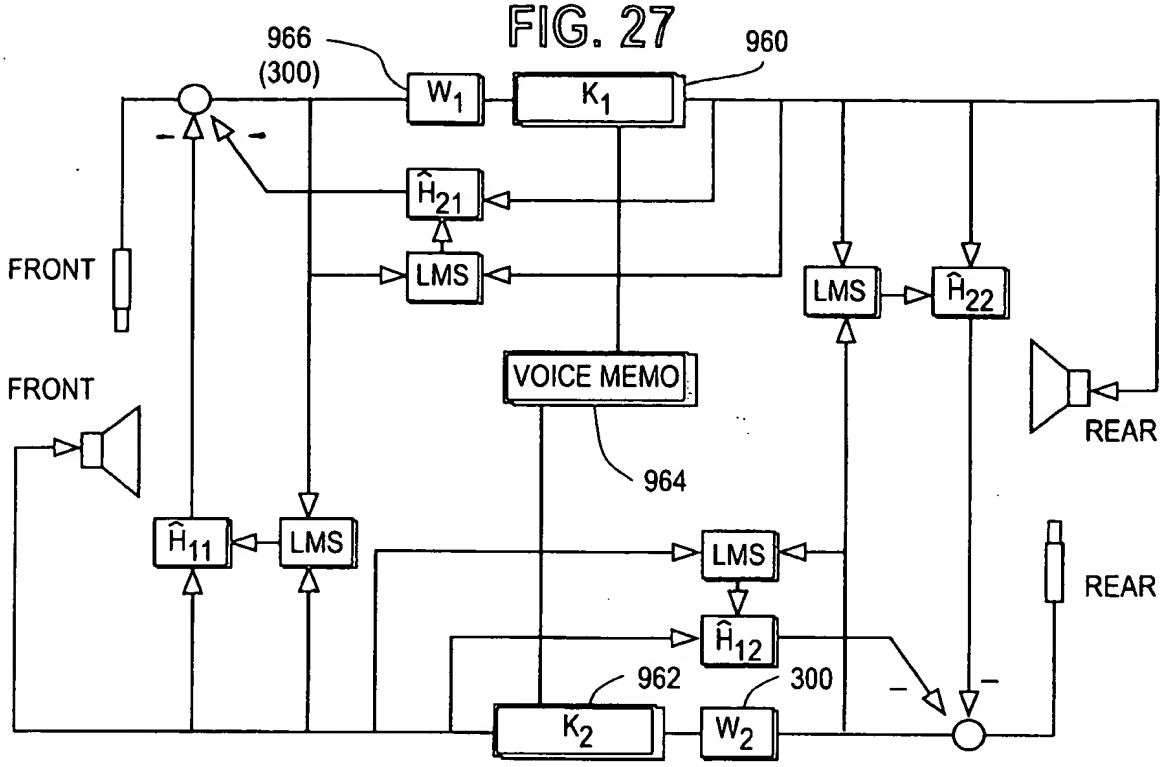
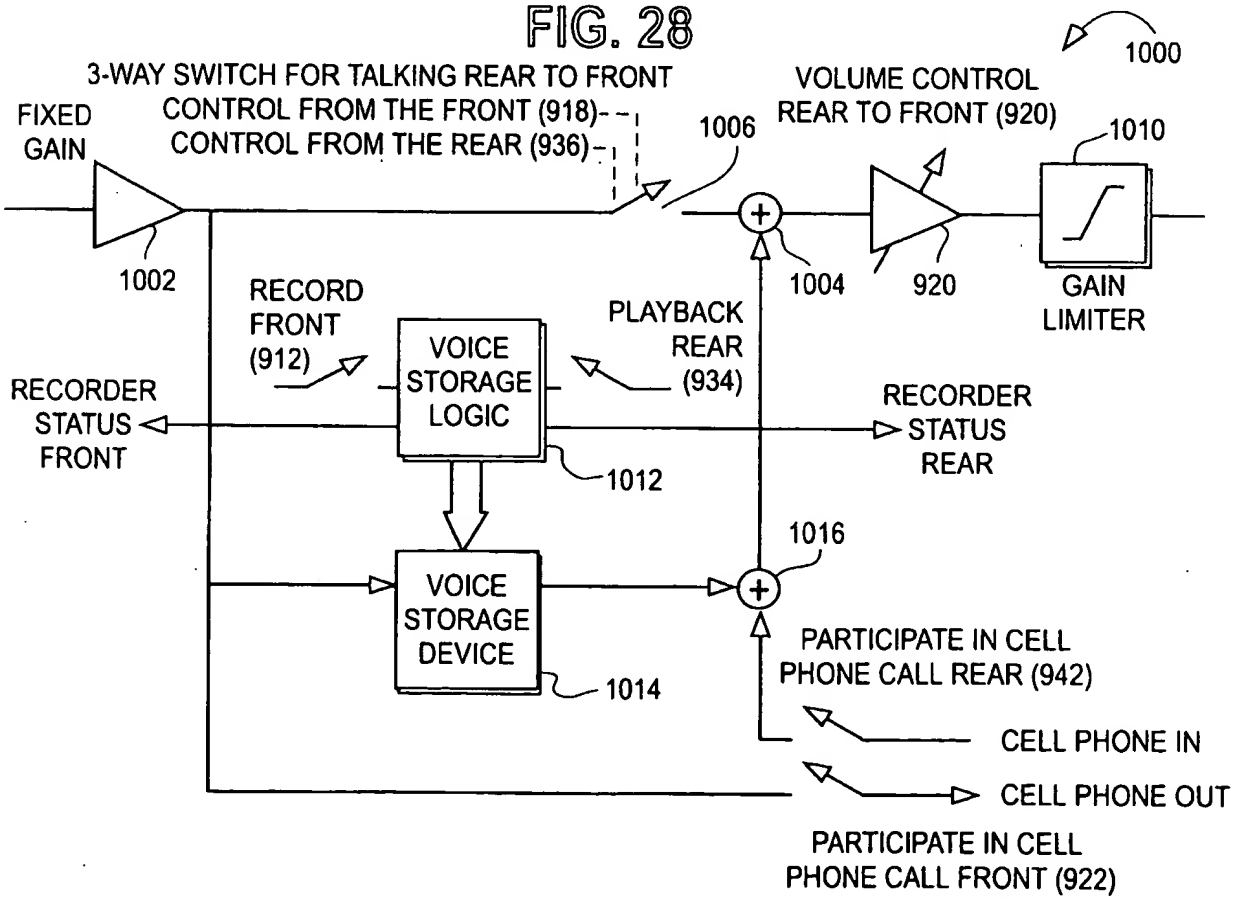

966
(300)
960
W_1
K_1
$\hat{H}_{21}$
LMS
FRONT
FRONT
LMS
$\hat{H}_{22}$
VOICE MEMO
964
REAR
$\hat{H}_{11}$
LMS
LMS
REAR
$\hat{H}_{12}$
962
300
K_2
W_2

FIG. 28


1000
3-WAY SWITCH FOR TALKING REAR TO FRONT
CONTROL FROM THE FRONT (918)
CONTROL FROM THE REAR (936)
FIXED GAIN
1006
VOLUME CONTROL REAR TO FRONT (920)
1010
1002
1004
920
GAIN LIMITER
RECORD FRONT (912)
VOICE STORAGE LOGIC
PLAYBACK REAR (934)
RECORDER STATUS FRONT
RECORDER STATUS REAR
1012
1016
VOICE STORAGE DEVICE
1014
PARTICIPATE IN CELL PHONE CALL REAR (942)
CELL PHONE IN
CELL PHONE OUT
PARTICIPATE IN CELL PHONE CALL FRONT (922)